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EIGHTH GENERAL ASSEMBLY OF THE INTERNATIONAL ASTRONOMICAL UNION

BY A. VIBERT DOUGLAS

ASTRONOMERS from thirty-four countries and the Vatican City State met together in Rome for the I.A.U. General Assembly from September 4–13, 1952, under the presidency of Professor Bertil Lindblad, Director of the Stockholm Observatory.

More than 430 names were listed as participants. The Italian committee under the convenership of Professor Giorgio Abetti had made admirable arrangements for the congress. The National Research Council provided its fine building near the entrance to the Cita Universitaria as headquarters, and its distinguished president, Professor G. Colonnetti, welcomed the delegates at the Inaugural Ceremony in the historic municipal palace at the Campidoglio on the Capitoline hill. At the Campidoglio also, the evening reception was held with its opportunities for informal meeting of old and new friends from many countries, in the setting of frescoed rooms, corridors hung with art treasures, the extensive stone terrace where a string orchestra played, and below in the lovely walled garden with its flowers and fountains, trees and statuary. For those of us who met her, the interest of that gathering was widened beyond the limits of astronomy by the presence of a citizen of Rome who has watched the history of her country for three score years and ten and played her part in her country's life with vigour and with devotion to the great family tradition, Miss Rosa Garibaldi, granddaughter of the man whose name is still one to conjure with in Italy.

The general meetings were held in the Aula Magna of University City, the Commissions and Symposia in the excellent classrooms of the Institutes of Physics and of Mathematics. Draft reports of thirty-three commissions were available. In addition to the meetings of the commissions, either singly or in joint sessions on interrelated subjects, a special feature

was the introduction at this assembly of symposia on solar and terrestrial relationships, stellar evolution, astronomical instruments, spectra of variable stars, and on the astrometry of faint stars.

The symposium on stellar evolution was opened by Professor V. Ambartsumian of the U.S.S.R. He discussed two kinds of stellar "associations", O and T, the former comprising mostly the high luminosity O to G stars, the latter the G to M stars in the lower part of the main sequence. Stars are being born into both these kinds of associations at the present time. A discontinuity exists in the early G stars as to luminosity and velocity indicating a distinct separation of the O and T associations. Parenago and Masevitch believe the internal structures of these two groups of stars are different and are due to two mechanisms which are operating in the galaxy. Stars are formed in the filaments and the "caillots" of diffuse nebulae. Evolution of stars due to accretion is ruled out by the facts as interpreted by Russian astronomers.

Papers followed by Fessenkov and Shajn. The former claims that surrounding certain stars are small dark halos and he interprets these as relative rarefactions in the cosmic dust around the star due to repulsion. Gurzadian has investigated the interaction between stars and interstellar hydrogen, with results contradicting conclusions of Hoyle, Lyttleton, Bondi and Weizsäcker, who regard accretion as a major factor. Fessenkov stressed the important part played by corpuscular radiation in stellar evolution. Shajn's paper dealt with the intricate structure of filaments in diffuse gaseous nebulae, revealed in his photographs taken in the light of Hα. Fine reproductions of a dozen of these beautiful plates accompanied his paper which, with those of Ambartsumian and Fessenkov, were given to every delegate in the three languages—Russian, Italian and French. Shajn emphasized the intrinsic importance of electromagnetic forces, not merely or even primarily gravitational force, in explaining the structure and behaviour of ionized nebulosity and the conditions requisite for the formation of great groups of hot stars, "associations", or of isolated stars.

This symposium continued with papers by Lindblad and Oort. The latter discussed expanding motions in groups of early-type stars, the perturbing force of the galaxy becoming effective after 10 million years in elongating the group, the ages of groups being proportional to the axial ratio. Baade contributed a paper on young and old stars; the former are high luminosity O and B stars and associated stars of lesser mass which form population I, all originating in the large gas and dust regions composing the spiral arms of galaxies; the latter are found in

globular clusters and their evolutionary track up or away from the main sequence depends upon their hydrogen content and the degree of mixing. If the hydrogen-exhausted core contains about 10 cent. of the star's mass rapid departure to the right of the main sequence takes place and population II stars are therefore old stars with ages of the order of 3×10^9 years and greater. The young stars are 10^7 years and less.

Hoyle followed with a discussion of the role of accretion in the birth of a star and in binary star evolution. His ideas were strongly criticised by the U.S.S.R. delegates. Greenstein and Schwarzschild discussed the chemical composition of stars of population II (deficient in heavy elements, perhaps formed from early gaseous clouds before much dust had developed) and of population I (rich in heavy elements and of recent birth in the dust and gas cloud regions). Schatzman who had largely organized this valuable symposium brought it to a conclusion with a paper on white dwarfs. Among those contributing to the general discussion were Alfven, Kuiper, Masevich, Lyttleton, Bondi and Gold.

Commission 12 on solar radiation under the chairmanship of Dr. Minnaert provided interesting reports by Nicolet on the distribution of energy and of the urgent need for an absolute measurement at some wave-length; by Dodson on the McMath 70-foot solar tower infra-red atlas, and the evidence for nitrous oxide and carbon monoxide and several isotopes in molecular bands; by Brück of Dunsink and by Severny of Pulkova on tracing line profiles. As in 1948 at the Zurich congress, emphasis was laid on the need for more accurate measurements of both the solar constant and the solar magnetic field.

Commission 10 on photospheric phenomena under Dr. Waldmeier ran into a debate on the method of recording sun-spot areas—Allen wants projected areas, Newton wants both projected and corrected areas, the U.S. Naval Observatory by the photographic method in use can give only the latter. Another debate centred around the merits of referring polarization phenomena to the plane of vibration or the plane of polarization. This was in Commission 34 on interstellar matter. Hall, Zanstra, Swings, Menzel and Drefus had strong opinions on this and on nomenclature for regions of H and H ions. The valuable report by Otto Struve included summaries of the work of about 22 Russian astronomers on interstellar dust, general and selective absorption, sizes of particles up to 100 millimetres in lower galactic latitudes, effects of absorption on star counts and colours and the dimensions of clusters, and metagalactic absorption estimated at $0^m.025$ per megaparsec. Gold discussed the electromagnetic fields in interstellar space as proven by the polarization of starlight and

sketched the outline of his forthcoming theory based upon the relative velocities of dust-particles and gas and their orientation to the galactic plane.

To Commission 40, set up in 1950 to embrace radio-electric observations, Ryle described the location by radio interference of two intense sources, Cas 23 N58 and Cyg 19 N41, the former about 5′.5 in diameter, the latter 3′.6. Baade reported that the 200-inch was used on these areas with interesting results. The Cassiopeia region contains a nova-like nebulosity with filaments, spectra of which show Doppler shifts up to 1500 km. per sec. One filament shows H lines, another does not. These present a new phenomenon. The Cygnus region shows two external galaxies interpenetrating with high excitation spectra, nebular emission lines, and a red shift of 16,500 km. per sec. One other region is known where two galaxies are colliding and an emission spectrum produced. Baade urged that this region be investigated for radio noise. The inference was drawn by Hoyle and Gold that the source of radio noise appears to be a region of gas in violent motion, such turbulence being found in various places in our galaxy and in M 31 and other galaxies, in supernova shells, and where two galaxies are in collision.

Reporting on radio noise from the sun, Ryle stated that at wavelengths 60 centimetres to 7.9 metres the radio intensity at the equator extends to 30 radii. Dodson reported on 194 flares in 1948–50 of which 151 were accompanied by radio bursts on 200 megacycles. Sometimes the radio preceded the optical phenomenon, sometimes followed it, and sometimes they were concurrent.

Commission 28 on extra-galactic nebulae received an intensely interesting report from Baade on a re-determination of the distance scale by means of classical Cepheids which involves a factor of about two. Thus M 31, being twice as far away as previously believed, is therefore of a size comparable to or greater than our galaxy. (One recalled the voice of Eddington twenty-five years ago protesting against the premature declaration of some astronomers that our galaxy was a continent and all the others mere islands!). Questioned by Shapley, Baade gave the details of the investigation on 4-day Cepheids in the nucleus of M 31 leading to a correction of $-0^{m}.8$ in the Cepheid period-luminosity relation. Oort reported that connecting some galaxies there appeared to be luminous matter with some spectroscopic evidence that it is gaseous and partly oxygen.

The Joint Commission on spectroscopy under chairmanship of Dr. Meggers discussed at length the new tables of wave-lengths and the need of extensions of these, with Unsöld and others pleading the relative

importance of various weak spots in our present knowledge and urging concentration on what each felt to be most urgent. Herzberg's provisional report on spectra of polyatomic molecules was received with much appreciation.

At the final general assembly of the Rome Congress two important announcements were made: the election of Professor Otto Struve of the University of California as President of the Union for the forthcoming three years, and the decision (effected by polling each country) to accept the invitation of Eire to hold the next congress there in 1955.

Many meetings of course were going on simultaneously so that delegates attending some commissions completely missed others. The above brief outlines indicate only a part of what went on during a busy week. Three expeditions had been arranged, one to Castel Gandolfo where the Vatican Observatory is now admirably housed and where His Holiness Pope Pius XII welcomed the congress and read a speech in French, afterwards blessing the faithful individually and shaking hands with the others most cordially. Everyone was impressed with the astronomical equipment, the astrophysical laboratory, and the situation on one ridge of the volcanic Monti Albani by the deep blue crater lake a thousand feet above sea level. The second trip was to Monte Mario on the western outskirts of Rome where solar work is carried out. Lastly was the excursion to Ostia where extensive early Roman excavations were visited and the closing dinner was held by the shore of the Mediterranean at Ostia Lido with the National Research Council as hosts.

To the Royal Astronomical Society of Canada which named me a member of the Canadian National Committee of the I.A.U. my warmest thanks are extended, and likewise to the other members of this Committee for electing me a delegate to the VIII General Assembly of the I.A.U. These meetings have re-established invaluable personal contacts and made possible increased co-operation in astronomy and allied sciences.

Queen's University, Kingston.

EMISSION-LINE STARS IN GALACTIC NEBULOSITIES*

By George H. Herbig
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Introduction

It is now about a decade since A. H. Joy[1] recognized the existence of a class of variable stars with very distinctive spectral characteristics, whose members apparently occur only in association with nebular material. These objects have come to be known as "T Tauri variables". At approximately the same time, photometric observers in Germany (notably K. Himpel and C. Hoffmeister) were studying the light curves of a number of irregular variable stars that they have assigned to the so-called "RW Aurigae type"; some of these, like all of the T Tauri stars, are located in nebulous regions. Although RW Aurigae itself and several other "RW Aurigae variables" have the spectroscopic characteristics of the T Tauri stars, it must not be inferred that the assignment of a variable star to the RW Aurigae class of variables on the basis of its light-curve alone necessarily means that that star must have a spectrum of the T Tauri type. As a matter of fact, spectroscopic observation of variables that have been assigned to the RW Aurigae type without prior knowledge of their spectra demonstrates that it is apparently quite difficult to pick out T Tauri stars solely on the basis of the characteristics of the light-curve. The T Tauri stars are a well-defined and physically significant group; it is not at all certain that the RW Aurigae variables meet the latter condition.

It is not intended to impute that all the variable stars genuinely associated with nebulosity have emission spectra of the T Tauri type, for they certainly do not. Studies of the extensive groups of variable stars associated with the Orion Nebula and with the nebulous cluster NGC 2264, which will be described presently, indicate that in these systems only a portion of the known variables possess emission spectra; the fraction of known variable stars that have a bright $H\alpha$ line at any one time is 0.5 in the Orion Nebula and 0.7 in NGC 2264. This point should be kept in mind in the discussion to follow: in confining attention to those stars in nebulae that have bright lines, as will be done here,

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Third paper presented at the symposium on "Emission-line Objects," American Astronomical Society meeting, Victoria, B.C., June 1952.

[1] *P. A. S. P.*, vol. 54, p. 15, 1942; *Ap. J.*, vol. 102, p. 168, 1945; vol. 110, p. 424, 1949.

we are ignoring a considerable number of stars whose association with the nebular material cannot be questioned.

It seems, at the present moment, that the spectra of almost all of the emission-line stars that are found solely in association with nebulae can be assigned to one of four groups. These groups are, in order of decreasing population: (A) stars of the T Tauri type, (B) stars with strong H absorption lines, (C) stars whose spectra suggest luminosities above the main sequence, and (D) peculiar objects with strong emission lines and weak continua. The boundaries between the groups are rather indefinite, and intermediate objects are known. It is possible that future work will show this grouping not to be an adequate or even a significant one, but it has the advantage of being able to contain the great majority of these objects now known. It will be noted that the term "T Tauri star" is used here in a more restricted sense than has been the practice heretofore. A brief description of each group follows.

A. *The T Tauri Stars.* The spectra of these objects have been described in detail by Joy. Some members have intense emission spectra that resemble, in a general way, that of the solar chromosphere: i.e., they possess bright lines of H, CaII, as well as of the neutral and especially the ionized metals. [SII] and HeI often appear as well. Such strong emission spectra as these, which are exhibited by RW Aurigae, RU Lupi, and XZ Tauri, for example, are in the minority. More common, especially among the less luminous objects, are spectra with strong H and CaII emission lines, but with much weaker lines of FeI, FeII, HeI, and [SII]. The underlying absorption spectra are often seen only with difficulty, especially when the emission features are strong. In all cases where classification is possible, the spectral types range from F8 to early M, while the spectroscopically assigned luminosities are those of main-sequence stars. A division of Group A into subclasses is possible on the basis of emission-line criteria.

B. *Stars with Strong Absorption Lines of Hydrogen.* These objects would be placed in spectral types A or F from the strength of their hydrogen absorption lines alone. One of the brightest objects of this group is B.D. -6° 1253, with an absorption spectrum between types A2 and A5. The emission spectrum is the strongest of any known star in the group; it resembles those of the T Tauri stars but the level of ionization is markedly higher. Six other stars of the group are known: they include the well known objects T Orionis, R Coronae Australis, and HK Orionis. It is interesting to note that every star now assigned to this group illuminates a reflection nebula. In the fainter members of Group B, the emission spectrum may be quite weak: two have only a bright $H\alpha$ line. It is not at

all certain that the hydrogen absorption lines in every star of Group B are formed in a normal A- or F-type stellar atmosphere.

C. Stars whose Spectra Suggest Luminosities above the Main Sequence. Only a few of these objects are known. They may be peculiar members of Groups A or B. The best example is probably the irregular variable BF Orionis, which lies not far from the Orion Nebula. The spectral type is about A5, and the luminosity class is II-III on Morgan's system. Hα is bright, and emission is sometimes visible at Hβ. Another member is SU Aurigae, an irregular variable that has been classified as a G2 giant at Mount Wilson. It shows weak emission in H and K, and illuminates a small bright reflection nebula. The nova-like variable FU Orionis may be related to Group C. It has a somewhat abnormal spectrum of F type, with indications of high luminosity; there is weak emission at the H and K lines. It lies in a dark cloud and illuminates a small bright nebula.

D. Peculiar Objects with Strong Emission Spectra and Weak Continua. These curious objects were first found in the dark nebula surrounding B.D. $-6°$ 1253.[2] Their spectra show bright lines, both permitted and forbidden, of a very wide range of excitation. Information available on these objects is very scanty at the present time.

The underlying absorption spectra of most objects of Group A have usually been regarded as resembling the spectra of normal stars of the main sequence, when allowance is made for the interference of emission features. If these are normal stars, the question arises if they are ordinary field objects that have moved into the nebulae and exhibit emission spectra and light variations as a result of some interaction process with the nebular material, or whether they are young stars that have been formed within the clouds. The Russian astronomers V. Ambartsumian and P. Kholopov, in their studies of stellar associations, have given the name "T-associations" to the groups of irregular variables in the dark clouds of Taurus, Corona Australis, and elsewhere. They believe that the T-associations are composed of newly formed, main-sequence stars, which in the early stages of their lives behave as unstable objects with irregular variations in light. Some new evidence that may support this hypothesis of Ambartsumian and Kholopov will be presented later, but it will be seen that this evidence is somewhat ambiguous. The question may be regarded as the most fundamental one in the subject at the present time.

Since the appearance of Joy's pioneering paper in 1945, a considerable amount of observational work has been done on the emission-line stars in nebulae, but it does not seem that the subject at the present time is in

[2]Herbig, G. H., *Ap. J.*, vol. 113, p. 697, 1951.

a condition such that a comprehensive review would be worthwhile. At this time, therefore, it is proposed not to make a survey of the subject but rather to give an account of some new observational results in this field. This report deals with three matters: first, new results on the occurrence of emission-line stars in the Orion Nebula and NGC 2264; second, some data on the absolute magnitudes of the emission-line stars in Taurus and Auriga; third, some preliminary results of a study with high dispersion of the absorption spectra of four bright emission-line stars.

Emission-line Stars in the Orion Nebula and NGC 2264

If the emission-line stars are the result of chance encounters between field stars and nebulosity, then their number in a given nebula should be proportional to the surrounding star density as well as to factors depending upon the nebula in question. Consequently we should expect to find unusually large numbers of bright-line objects in star clusters associated with nebulosity. During the fall and winter of 1951-2, the two most suitable objects accessible from Mount Hamilton, the Orion Nebula and NGC 2264, were systematically searched for emission-line stars with the new grating slitless spectrograph of the Crossley reflector.

Before the results of this survey are presented, a brief description of this spectrograph is in order. It is essentially the result of combining a Ross zero-power coma-correcting lens with a large replica transmission grating. The combination of a red filter and the Eastman 103*a*-E emulsion isolates a short spectral region between λ6300 and λ6700 for the observation of the Hα line at λ6562. The grating concentrates a large fraction of the incident energy in the direction of the first-order red on one side; the dispersion in that order is about 450 A. per mm. The field of the spectrograph is 43 by 53 minutes of arc; the images are good and their quality is adequately uniform over this region. The faintest stars in which Hα emission has been detected, on a 60-minute exposure, are near photographic magnitude 18.5.

The region of the Orion Nebula has been examined previously for bright Hα stars by G. Haro[3] with the Tonanzintla Schmidt camera and an objective prism. The Lick survey was quite similar but was made with short exposures (20 minutes in length) and hence reaches a limiting magnitude about one magnitude brighter than Haro's. Nevertheless, the number of bright-line stars discovered by the two surveys in the same 2.5 square degree area centred on the Trapezium is not greatly different: Haro found 113 such stars, while the Lick plates show 90 between photographic magnitudes 9 and about 17. The total area covered by the

[3] *A. J.*, vol. 55, p. 72, 1950.

Crossley plates was 6.7 square degrees; 13 additional emission-line stars were found outside the central area.

NGC 2264 is a cluster whose brightest member is the fourth-magnitude O7 star S Monocerotis. The cluster is associated with an extensive dark nebula, at a distance of about 700 parsecs, and illuminates several patches of both emission and reflection nebulosity. Twenty faint variable stars were discovered in and about the cluster by Max Wolf;[4] others were found by C. Hoffmeister,[5] and by Herbig on Crossley plates. Eleven of these variables were observed with a slit spectrograph at Mount Hamilton in 1950;[6] at that time, five were found, and two others were suspected, to have emission spectra of the T Tauri type. The plates of the region obtained since then with the Crossley grating slitless spectrograph and exposure times of 60 minutes show 76 emission-line stars between photographic magnitudes 13.8 and 18.5.

The detailed results of this work will appear elsewhere; some of them are summarized in Table I, which compares the emission-line star populations of the Orion Nebula, NGC 2264, and the Taurus-Auriga dark clouds. The data for the Taurus-Auriga stars are taken mainly from the work of Joy.

TABLE I

STATISTICAL DATA FOR EMISSION-LINE STARS IN THE ORION NEBULA, NGC 2264, AND THE TAURUS-AURIGA CLOUDS

Nebula	Obsc. area surveyed in sq. deg.	m_{pg} of brightest em.-ln. star[1]	M_{pg} of brightest em.-ln. star[2]	No. of em.-ln. stars per proj. sq. psc.		Lim. M_{red} of survey	No. of var. examined for bright Hα	Fraction of var. with bright Hα at any one time
				Central region	Av. for obsc. area surveyed			
Orion Neb.	4.7	{9.5[3] / 12.0[3]}	{+0.5[3] / +3.0[3]}	3.	0.8	+5.5	115	0.47
NGC 2264	1.2	14.0[5]	+5.0[5]	2.	0.4	+6.5	21	0.69
Tau-Aur	26.	9.5[4]	+3.5[4]	—	0.2	+9:	—[6]	—[6]

[1]These values have in all cases been rounded off to the nearest 0.5 mag. For the Orion Nebula and the Taurus-Auriga clouds, they are the apparent magnitudes of known variables at maximum light. The value for NGC 2264 is the mean photographic magnitude of the four brightest stars, as obtained from one photograph.

[2]These values of the photographic absolute magnitudes have been obtained by applying apparent moduli of +9.0 for the Orion Nebula and NGC 2264, and +6.0 for the Taurus-Auriga clouds.

[3]These values refer to maximum light of the bright, type A3eα variable T Orionis, which belongs to Group B.

[4]These values refer to maximum light of the brightest variables of Group A.

[5]These magnitudes depend on a single photograph. Since these stars are very likely variable, continued observations comparable to those upon which the Orion and Taurus-Auriga results are based would yield brighter magnitudes for the maxima of the NGC 2264 variables.

[6]These data are not available for the Taurus-Auriga clouds.

The brightest Group A, or T Tauri stars, in the Orion Nebula and the Taurus clouds are of late F or early G type; there is as yet little information available on spectral types in NGC 2264. The brightest Orion and

[4]*A. N.*, vol. 221, p. 379, 1924.

[5]*Mit. A. Gesell.*, 1951, p. 20.

[6]Herbig, G. H., *P. A. S. P.*, vol. 62, p. 142, 1950.

Taurus stars are somewhat brighter at maximum light than the absolute magnitudes corresponding to their spectral types, as is shown by the entries in the fourth column of Table I.

The projected surface density of emission-line stars in NGC 2264 is higher than in the Taurus clouds, while that in the Orion Nebula is higher still. This is shown directly by the values in the sixth column, despite the fact that the search in Taurus extended to a limiting absolute magnitude about $2^m.5$ fainter than that in NGC 2264, and about $3^m.5$ fainter than that in Orion. These densities are, of course, in the unit of stars per square parsec projected upon the plane of the sky; in the absence of information on the structure of the nebulae, these densities cannot be converted into stars per square parsec projected normally upon the nebular surfaces.

These observations demonstrate that there is an actual excess of emission-line stars associated with the star clusters in the Orion Nebula and NGC 2264. This result cannot be considered a proof, however, that the bright-line objects are merely normal main-sequence cluster members that exhibit emission as a result of the accidental encounter of cluster with dark cloud; it might be claimed that the entire cluster has recently been formed out of the nebular material and that the emission-line stars are young, still unstable stars, as proposed by Ambartsumian and Kholopov.

The Absolute Magnitudes of the Emission-line Stars in the Taurus-Auriga Clouds

Joy discovered that several of the T Tauri stars in the Taurus clouds were double, and he noted a curious discrepancy between the observed differences in magnitude between the components and those inferred from the spectral types. The discrepancy was in the sense that the two stars were closer in apparent brightness than they should be, if the spectroscopic absolute magnitudes were correct. In the last few years, fairly accurate magnitudes have become available for most of the emission-line stars in Taurus-Auriga, and these data demonstrate that the phenomenon observed by Joy in the double stars is a general one, present in single stars as well.

The distance of the dark clouds in Taurus is fairly well known; the studies of S. W. McCuskey[7] and of J. L. Greenstein[8] gave mean distances of 142 and 145 parsecs, respectively. For the present purpose, a distance modulus of $+ 6^m.0$, corresponding to a distance of 150 parsecs, was adopted. The photographic magnitudes of about 30 of the bright-line

[7] *Ap. J.*, vol. 89, p. 568, 1939.
[8] *Harv. An.*, vol. 105, p. 359, 1937.

stars found by Joy have been determined by P. Kholopov and N. Kurokin[9] on Moscow and Simeis plates, and by O. J. Eggen and Herbig from photoelectric observations at the Lick Observatory. Spectral types have been assigned to all of these stars by Joy. In figure 1, the difference between the predicted m_{pg} for each star, obtained by combining the M_{pg} corresponding to Joy's spectral type and the distance modulus of $+ 6^m.0$, and the observed m_{pg} is plotted against spectral type. The ordinate of figure 1 thus gives the excess or defect in the observed brightness of each star over that expected from the spectral type and distance. A star plotted *above* the m_{pg} (predicted) $- m_{pg}$ (observed) $= 0.0$ line is therefore too *bright*. All of the stars plotted are variable; the vertical lines indicate the light range found by the Russian observers. The open circles indicate the mean result from the photoelectric observations; since only one to three photoelectric observations were available for each star, the limits of the light variation could hardly be determined independently.

Figure 1 shows a remarkable phenomenon: beginning at spectral type K4 or K5, the late-type emission-line stars (all members of Group A) exhibit an excess brightness whose amount increases as the type becomes later, and which reaches a value of about $+ 2^m.5$ at type M2–M3. The G-type stars, on the other hand, have mean apparent magnitudes that either lie near the expected values or are too faint. One would be inclined to ascribe the deficiencies of the faint G-type stars to greater-than-average absorption by nebular material. This explanation is inadmissible, however, because photoelectric colours are available for a group of four of the bright G-type stars that lie near the 0^m axis of figure 1, and for a group of three of the G-type stars that average $2^m.5$ too faint. The mean colour indices of the two groups are $+ 0^m.8$ and $+ 1^m.0$, respectively. If the usual ratio of photographic absorption to colour excess is applicable here, then this small colour difference would indicate a difference in absorption of about $0^m.9$, rather than the $2^m.5$ actually observed. A more likely explanation is that the spectral types of the faint stars are classified as too early. These particular stars have such strong emission spectra that the absorption lines are seen only with difficulty. Joy called them merely type Ge; they have been placed at G5 in figure 1. If they were in reality of type K, the anomaly would disappear. Another possible explanation is that the strong emission lines in the photographic region cause them to appear too blue.

It is probable that the increase in the amount of the excess brightness with later spectral type is real. The position of the zero-point of the

[9] *Variable Stars*, vol. 8, p. 83, 1951.

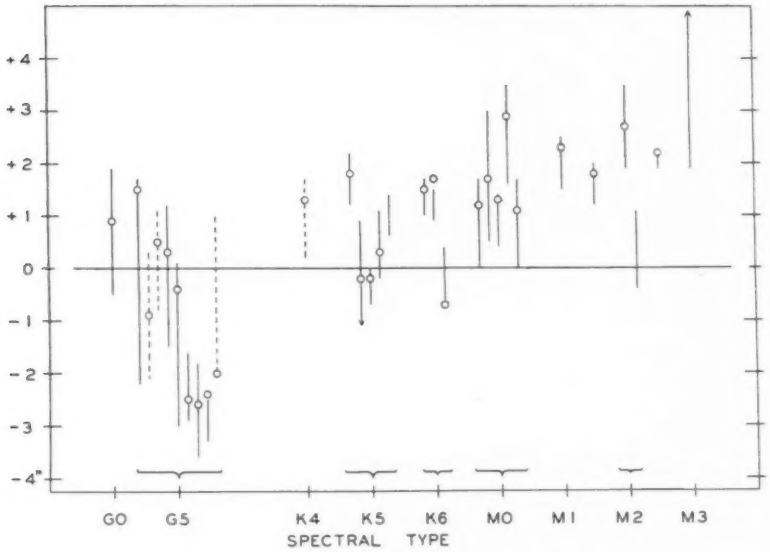


FIG. 1.—The Departures of Emission-line Stars in the Taurus–Auriga Dark Clouds from Normal Absolute Magnitudes. The abscissa is the spectral type as assigned by Joy. The ordinate is the excess (positive values) or defect (negative values), in magnitudes, of the observed brightness over that predicted from the spectral type and distance. The vertical lines indicate the light variations found by Kholopov and Kurokin; open circles correspond to the mean photographic magnitudes as determined from a small number of photoelectric observations made by Eggen and Herbig. The vertical line in the upper right, which passes out of the diagram, corresponds to UZ Tauri. Dashed vertical lines correspond to variables for which no allowance could be made for the contribution of a companion star. An arrowhead pointing downward on the line for one variable indicates that the minimum magnitude was not observed.

ordinate scale depends on the modulus adopted, but in order to move the 0^m axis upward in the diagram by $3^m.5$, i.e. above the maximum-magnitude points of all the stars except UZ Tauri, the distance of the dark nebulae would have to be diminished to about 30 parsecs, which is unreasonable in the light of other information.

The source of the anomalous Δm's observed by Joy in the double stars is now clear: the observed Δm values were discrepant because the late type companions are usually too bright (and in some cases, the primaries are too faint) for their spectral types.

In recent years, the existence of a continuous spectrum of unknown origin has been recognized in the T Tauri stars. This continuum fills in

the absorption lines, sometimes to the extent of nearly obliterating them. It is natural to ask if this continuum may not be contributing the excess energy required to raise the late-type stars above the 0^m axis of figure 1. It does not seem likely that this is the case, for several reasons: (1) Those stars having spectra heavily veiled by this continuous spectrum do not necessarily lie high in the diagram of figure 1. (2) The emission-line stars DH and DI Tauri[10] lie only 16 seconds of arc apart and have almost identical radial velocities, so that they probably form a physical system; they are closely similar in spectral type: Joy gives dM0 and dM0.5, respectively. The absorption spectrum of DH Tauri is heavily veiled by continuous emission, while that of DI Tauri is not, yet the apparent magnitudes of the two stars are very nearly the same. This observation shows that the emission continuum cannot contribute very much additional energy. (3) It does not seem that the continuum can be regarded as an independent and additive contributor of energy to the output of the dwarf star on whose spectrum it is superimposed, for it would be incredible if an independent source could add enough energy to raise the total light by 3 magnitudes, and still permit the absorption lines of the star to remain visible at all.

If the data that have gone into figure 1 are substantially correct, it is necessary to conclude that the late-type emission-line objects in the Taurus-Auriga dark clouds do not have the energy output, in the accessible part of the spectrum, that we regard as normal for stars with their spectral types and spectroscopic luminosities.

The Absorption Spectra of the Emission-line Stars

It would seem that a careful examination of the underlying absorption spectra of these emission-line stars might aid in a decision as to whether they are normal dwarfs or not. Progress in this direction is not easy. The brightest known stars of this type attain photographic magnitudes of only 9.0 to 9.5 at their maxima, so that they have usually been observed with moderate or low dispersion. Furthermore, the presence of line and, sometimes, continuous emission often interferes seriously with the visibility of the absorption spectrum. Joy and others were able, however, to assign spectral types and luminosities to most of the emission-line stars observed with slit spectrographs. These results seemed to imply that, as seen with low dispersion and after allowance for contamination by emission, the underlying spectra are much like those of normal dwarfs. Joy commented, however, that in several stars where the absorption spectrum was well

[10]These are MHα 259–9n and MHα 259–9s, respectively, in Joy's list (*Ap. J.*, vol. 110, p. 426, 1949).

seen, the lines were wide, or shallow, or indistinct. In 1947, R. F. Sanford[11] obtained a high-dispersion spectrogram of T Tauri itself with the coudé spectrograph of the 100-inch telescope; the dispersion was 10 A. per mm. in the photographic region. Sanford remarked that "the absorption lines are somewhat shallow and diffuse for spectral class G." These indications that the absorption lines in some of the T Tauri stars are not sharp are, I believe, the only published evidence that the absorption spectra are not entirely normal.

In order to investigate this matter more fully, additional high-dispersion observations were necessary. In 1950 and 1951, through the courtesy of the Director of the Mount Wilson and Palomar Observatories, coudé spectrograms with a dispersion of 10 A. per mm. were obtained of seven of the brightest emission-line stars associated with the dark clouds in Taurus, Auriga, and Orion. The study of this material is not complete, but one preliminary result can be quoted here.

Inspection of these plates reveals immediately that, in each of the four bright-line objects[12] in which the absorption spectrum is generally free of serious interference by emission, the absorption lines are abnormally broad and diffuse compared to ordinary G- and K-type dwarfs. (See figure 2.) Photometry of these plates demonstrates that the appearance of the lines cannot be explained as the result of veiling by a weak

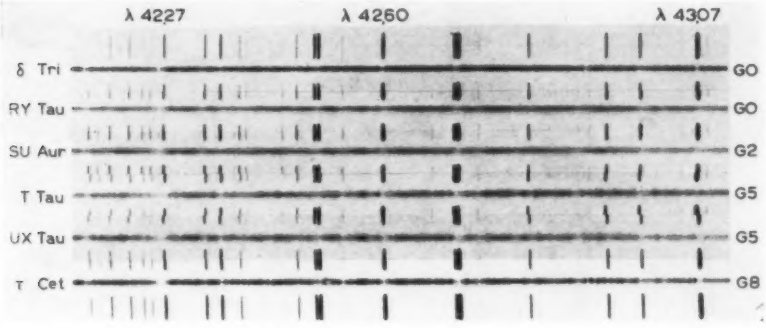


FIG. 2.—The Spectra of Four Emission-line Stars, and Two Normal Dwarfs, in the Region λ4213–λ4312. The widening of the absorption lines in the four variables, as compared to the normal stars, is well shown. The original spectrograms were obtained with the coudé spectrograph of the 100-inch Mount Wilson reflector.

[11] *P. A. S. P.*, vol. 59, p. 134, 1947.

[12] Two of the seven stars observed, RW Aurigae and B.D. − 6° 1253, have objectionably strong emission spectra for this purpose, while another, FU Orionis, was not used for this study since it may be either a slow nova or an object of Group C.

continuous spectrum; neither is it due to filling-in by discrete emission lines, although these effects may be present in other stars. There are certain other discrepancies apparent when these spectra are compared with normal dwarfs, but it is too early to say whether they are any more than curve-of-growth effects, or whether they arise because of the difficulty in comparing sharp- and broad-lined spectra.

The profiles in the emission-line stars were compared with the same lines observed in the normal dwarfs δ Trianguli (G0), κ Ceti (G5), and τ Ceti (G8). The spectrograms of both groups of stars were obtained with identical adjustments of the same spectrograph, and they were traced in the microphotometer under conditions as similar as possible. To the accuracy justified at this preliminary stage of the work, it is possible to represent the profiles in the bright-line stars as the result of the action of a broadening agent such as stellar rotation or large-scale turbulence. If the line profiles observed in the normal dwarfs are distorted by amounts that correspond to different rotational velocities of a star with a limb-darkening coefficient of $u = 0.6$, and they are then compared with the profiles in RY Tauri (G0), SU Aurigae (G2), and UX Tauri (G5), it is found that the mean value of $v \sin i$ for these three emission-line stars is slightly more than 50 km. per sec. The individual values for these three stars lie close to this mean; T Tauri (G5) has sharper lines than these three stars, but its lines are still perceptibly broadened. If the profiles observed in the normal dwarfs are broadened, not by rotation but by an error function

$$\frac{1}{\xi\sqrt{\pi}} e^{-(\Delta\lambda/\xi)^2},$$

then the mean value of ξ found for the same three stars is slightly less than 50 km. per sec. No information is available as yet on the curves of growth of these stars. The presence of wide lines in these four bright, typical emission-line stars, together with the result from low-dispersion spectrograms that other such objects have indistinct or diffuse lines, suggests that broad absorption lines may be a general property of these objects. It has been known for a long time, of course, that the *emission* lines are generally wide and diffuse, but one is hesitant in regarding bright lines as very trustworthy indicators of the motion of the underlying star.

It would be most interesting if detailed study of these line profiles would demonstrate that the broadening is due to rotation. Theoretical investigators[13] have had considerable difficulty in accounting for the

[13]Whipple, F. L., *Ap. J.*, vol. 104, p. 1, 1946; L. Spitzer, Jr., *Centennial Symposia* (Cambridge: Harvard Observatory, 1948), p. 100; C. F. von Weizsäcker, *Ap. J.*, vol. 114, p. 165, 1951.

disposal of the large quantity of angular momentum in a star either formed by condensation in a non-quiescent nebular medium, or "rejuvenated" by the accretion of material in such a cloud. Von Weizsäcker has stated that "even if most of the angular momentum is carried away, the stars must originate rotating."[14]

The equatorial velocities of rotation corresponding to the observed line breadths are much too small, unless the rotational axes of these four stars lie preferentially near the line of sight, to result in the rotational ejection of material from G- and K-type dwarfs. Such ejection would require equatorial velocities in the neighbourhood of 400 km. per sec.

Conclusions

The emission-line stars in nebulosity, which have been shown to constitute only a portion of the stars actually associated with the nebular material, occur in considerable numbers in the Orion Nebula and NGC 2264. Since unusual numbers of brighter stars also occur in the same regions, this fact alone does not tell us whether we are witnessing the chance encounter of a rich star cluster with nebular material, or the birth of the cluster from the cloud.

The absolute magnitudes of the bright-line stars associated with the dark clouds in Taurus-Auriga indicate that the stars of later spectral type are too bright for their spectroscopic luminosities. Furthermore, high-dispersion observations of some of these stars show that their absorption lines are abnormally wide, a characteristic that must be significant since narrow lines are the rule among ordinary dwarf stars of these spectral types.

These two observed facts—abnormally bright absolute magnitudes for the late-type objects and unusual absorption spectra—suggest that the emission-line stars in nebulae are not simply normal dwarf stars plus the source of the emission spectrum. It may be argued, however, that neither of these observational discrepancies is entirely irrefutable. It might be that these abnormalities are really rather superficial and may somehow arise from the process of interaction of a normal star with the nebular material. The absorption spectrum we observe may not be that of the underlying star at all, but rather that of a shell or cloud surrounding it. In other words, although the evidence at face value tends to support the proposals of Ambartsumian and Kholopov that these are abnormal objects, such an interpretation is not entirely free of objection. At this time, therefore, it is not possible to make a clearcut and entirely acceptable decision between the two opposing alternatives on the basis of observational evidence alone.

[14]Loc. cit., p. 184.

METEOR NEWS

By Peter M. Millman, *Dominion Observatory, Ottawa*

Visual Meteor Observations by L. A. Mathieu

During this past summer one of our most consistent meteor observers has been Mr. L. A. Mathieu at Craigflower, near Victoria, B.C. Between July 15 and Sept. 30 Mr. Mathieu has observed on 63 nights and has recorded a total of 1760 meteors, all timed, plotted, and magnitudes estimated. For systematic observing this is a record which is hard to beat.

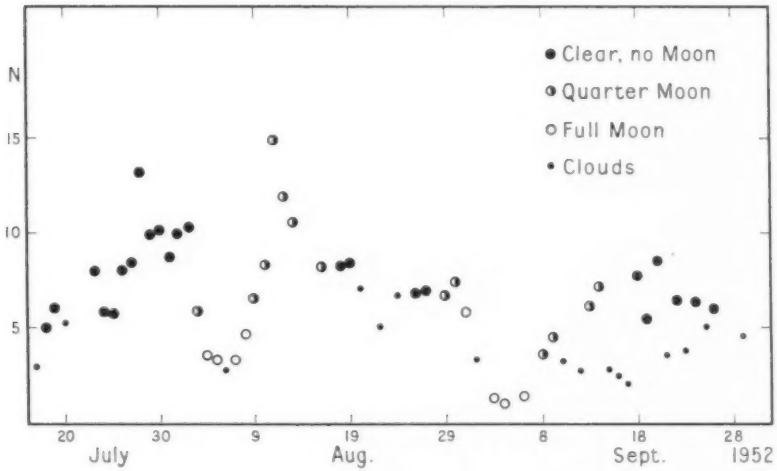
Mr. Mathieu is not a newcomer to the ranks of meteor observers. In Meteor News for 1940, Journal, vol. 34, p. 429, I reported on 901 meteors observed by him in the summer and fall of 1940. Then in 1946 Mr. Mathieu made another series of observations, including a really excellent record of 791 meteors observed on the night of Oct. 9–10 on the occasion of the great Giacobinid meteor shower. These latter will be published along with the report of other Canadian observations of this shower.

In Table I will be found a summary of the remainder of the observations made by this observer in 1946, the observing station being located at 293 St. Paul E., Montreal, P.Q. Table II contains a summary of the magnitude estimates from Aug. 5 to Nov. 1, 1946.

TABLE I

Montreal Observations, 1946

Evening Date (1946)	Observing Period E.S.T. (hrs.)	Total Observing Time (min.)	Meteors Observed	Remarks
July 23	2.3 – 2.9	29	0	haze
26	1.7 – 4.2	81	2	aurora
27	2.3 – 4.2	102	4	
30	23.2 – 4.5	136	6	
Aug. 4	0.3 – 4.6	218	7	
Aug. 5	3.2 – 4.9	99	4	
6	1.9 – 5.2	196	3	vis. 50%
7	0.0 – 5.2	309	5	vis. 30%
8	3.2 – 3.4	13	1	
10	22.8 – 4.6	178	15	some clouds
Aug. 11	21.5 – 5.3	287	33	clear
12	4.3 – 5.1	42	3	haze
Aug. 15-31	9 nights		33	
Sept. 2-28	18 nights		76	
Oct. 20-31	10 nights		55	
		Total	247	



Mean hourly meteor rates "N" for a single observer both plotting and recording. Observations made by Mr. L. A. Mathieu at Victoria, B.C., 48°.4 N, 123°.4 W.

The Victoria observations for 1952 up to the end of September are listed in Table III. To save space only the evening date has been given in the tables regardless of whether the observing period was before or after midnight. The average meteor rates for each night have been plotted in the figure. These are for a single observer both plotting, and recording the time, magnitude and train characteristics. The rates have been divided roughly into four catagories:

a—Nights when there was virtually no moon during the observing period and the sky was clear.

b—Nights when the moon within three days of the quarter phase was present and when the sky was clear or with possibly a very slight haze.

c—Nights when the moon within three or four days of the full was present.

d—Nights where observations were significantly hampered by clouds, haze or fog.

TABLE II

MAGNITUDE DISTRIBUTIONS, 1946

Mag.	−4	−3	−2	−1	0	1	2	3	4	5	6	Total	Mean Mag.
Aug. 5-Nov. 1	2		3	2	15	28	52	47	38	31	10	228	2.74

TABLE III
VICTORIA OBSERVATIONS, 1952

Evening Date (1952)	Observing Period P.S.T. (hrs.)	Meteors Observed	Remarks
July 15		1	clear
17	21.8 – 1.3	11	haze
18	22.5 – 2.7	21	clear
19	22.3 – 2.5	21	clouds 40 m.
20	22.7 – 1.3	14	clouds after 0 h.
23	0.5 – 3.5	20	clear
24	23.7 – 3.1	26	clear
25	23.5 – 3.5	22	few clouds
26	23.5 – 3.6	34	clear
27	22.7 – 3.5	40	clear
July 28	23.4 – 3.2	50	clear
29	22.8 – 3.5	46	clear
30	23.0 – 3.2	43	clear
31	23.7 – 3.5	42	clear
Aug. 1	0.0 – 3.6	35	clear
2	0.6 – 3.6	31	some moonlight
3	1.0 – 3.6	15	moon at first
4	1.7 – 3.8	8	
5	0.8 – 4.0	11	bright moon
6	0.8 – 3.3	7	clouds at end
Aug. 7	0.8 – 4.0	11	moon and clouds
8	0.8 – 3.8	14	moon
9	22.8 – 4.0	34	
10	22.9 – 4.1	43	
11	23.2 – 3.5	64	clear
12	23.1 – 4.3	64	clear
13	23.0 – 4.1	54	clear
16	23.0 – 4.0	41	clear
18	23.0 – 4.1	42	clear
19	23.0 – 4.5	47	clear
Aug. 20	23.0 – 3.0	28	hazy at end
22	0.5 – 4.5	20	some cloud
24	22.0 – 22.9	6	cloudy
25		2	
26	20.5 – 4.5	55	slight haze
27	20.5 – 4.5	56	clear
29	21.0 – 4.5	50	fog at end
30	2.0 – 4.5	26	very slight haze
31	22.0 – 4.9	40	bright moon
Sept. 1	23.0 – 4.8	19	cirrus and clouds
Sept. 3	0.0 – 4.6	6	bright moon
4	1.0 – 4.8	4	moon
6	20.2 – 0.0	4	moon
8	23.0 – 0.1	4	clear
9	20.0 – 2.0	27	clear, moon
10	20.0 – 5.0	29	clouds
12	20.0 – 5.0	25	hazy first 3 h.
13	21.2 – 4.7	46	clear
14	22.0 – 5.0	50	clear
15	22.0 – 4.0	17	some haze

(*Concluded on next page*)

TABLE III—*Continued from last page*

Evening Date (1952)	Observing Period P.S.T. (hrs.)	Meteors Observed	Remarks
Sept. 16	23.0 – 5.0	15	mostly clear
17	23.5 – 5.0	11	some fog
18	0.0 – 5.1	40	clear
19	0.0 – 5.0	27	clear
20	0.0 – 5.3	45	clear
21	0.0 – 5.2	19	haze
22	0.0 – 5.2	34	clear
23	0.0 – 5.0	19	haze and fog
24	0.0 – 5.0	32	some haze
25	0.0 – 2.0	10	clouds
Sept. 26	20.9 – 4.2	44	cloudy at end
28	21.1 – 23.3	1	partly cloudy
29	20.8 – 5.0	37	some haze
	Total	1760	

The nights of peak activity for the Delta Aquarids, on July 28–29, and for the Perseids, on Aug. 11–12, are clearly evident. There is no doubt that the Perseid peak would have been higher had the moon been absent for this shower. The decrease in rates at the full moon periods is also marked.

The magnitude distributions for the same four categories are given in Table IV. The lower mean magnitude for the full moon observations is to be expected. It is rather surprising that there is not more difference between the no moon and quarter moon values. It will be seen that these two distribution curves are almost identical. On comparing Table IV with Table II it would appear that there has been a change in Mr. Mathieu's personal equation for magnitude estimates in the interval. The mean magnitudes seem to average considerably fainter in 1952. Of course it is probable that his observing location in Victoria was much more favourable for the detection of faint meteors than that in Montreal.

TABLE IV

MAGNITUDE DISTRIBUTIONS, 1952

Mag.	−5	−4	−3	−2	−1	0	1	2	3	4	5	6	Total	Mean Mag.
Clear, no moon	1	1		1	1	12	47	97	133	171	262	28	754	3.70
Quarter moon				2	3	12	38	99	120	160	242	30	706	3.71
Full moon			1			2	12	13	14	19	18	2	81	3.15
Clouds						2	8	27	49	54	71	8	219	3.78

Persistent trains were noted in all cases where seen and an approximate estimate of duration recorded. A summary of these observations is given in Table V. To determine average train durations all train durations for a given brightness of meteor were summed and divided by the total number of meteors observed, as recorded in Table IV. This figure might better be decribed as the average tendency for trains to appear with meteors of a given magnitude. At first glance it might seem surprising that there were considerably more trains during the quarter moon but this is probably due to the presence in these periods of the Perseids, which are fast and have longer trains than the slower meteors (see JOURNAL, vol. 44, p. 211, 1950).

TABLE V

PERSISTENT TRAINS, 1952

Average train duration per meteor, in seconds.
(In brackets—percentage of meteors with trains.)

Mag.	< 1	1	2	3	4	5
Clear, no moon	1.34 (63)	0.90 (64)	0.34 (28)	0.16 (15)	0.03 (02)	0.00 (00)
Quarter moon	2.44 (88)	1.47 (76)	0.43 (35)	0.18 (20)	0.02 (02)	0.00 (00)

In conclusion I should like to congratulate Mr. Mathieu on his devotion to this work and to thank him for his contribution to meteoric astronomy.

OUT OF OLD BOOKS

By Helen Sawyer Hogg

The Introduction of the Copernican System to England

IV. Thomas Harriot, Sir Walter Raleigh's Surveyor and Topographer.

One of the most remarkable scientists in England at the end of the sixteenth century was Thomas Harriot. He was indeed a worthy successor to the ideas and skill possessed earlier in the century by Robert Recorde, John Dee, and Leonard and Thomas Digges. Unfortunately Harriot, in the three intervening centuries, has been little known as a scientist because he had the failing, common in the English school of this period, of not publishing his knowledge. Only one of his works was published during his lifetime. This was *A Briefe and true report of the new found land of Virginia*, in 1588. Some ten years after his death friends and pupils published his great work on algebra, *Artis Analyticae Praxis*.

Among their contemporaries, these English scientists whom we are discussing in this series of articles, had an outstanding reputation. Francis R. Johnson, in his valuable volume, *Astronomical Thought in Renaissance England*, (from which we quote by kind permission of The Johns Hopkins Press) cites the opinion of Captain Davis, the famous navigator, who listed Harriot, Digges, and Dee as the three English scientists living in 1595 who could surpass all foreign rivals in knowledge and skill. In the dedication of this book, *The Seamans Secrets*, Captain Davis wrote:

> For I think there be many hundreds in England that can in a farre greater measure and more excellent methode expresse the noble art of Nauigation, and I am fully perswaded that our Countrie is not inferiour to any for men of rare knowledge, singular explication, and exquisite execution of Artes Mathematicke, for what Strangers may be copared with M. Thomas Digges Esquire, our Countryman the great Archmastric, and for Theoricall speculations to most cunning calculation, M. Dee and M. Thomas Heriotts are hardly to be matched:

During these intervening centuries, however, little has been heard of Harriot except that he was the author of the Virginia report, previously mentioned, and of a work on algebra. In 1877 a learned gentleman, Henry Stevens of Vermont, founded the Hercules Club, whose purpose was research into early Anglo-American history and literature. Stevens became deeply impressed with the greatness of Harriot, and his undeserved

oblivion. Accordingly he gathered together a volume of material which, after Stevens' death was published by his son; *Thomas Hariot: The Mathematician, the Philosopher, and the Scholar*, London, 1900. This volume is now so rare that it can be of little help in spreading information about Harriot unless parts of it are reprinted. Only 195 copies of this book were printed, of which we have been privileged to use Copy no. 45 from the John Crerar Library, Chicago.

Stevens' admiration and respect for Harriot apparently grew enormously as he unearthed rare material by him and about him, including Harriot's will, missing for centuries. He calls Harriot "a man who, though long neglected and half forgotten, must eventually shine as the morning star of the mathematical science in England, as well as that of the history of her Empire in the West." Stevens sums up Harriot's obscurity as follows, (pages 128 and 160):

> The truth seems to be that Hariot was unlucky and fell into oblivion accidentally. He was a man of immense industry and great mental power, but perhaps careless of his scientific and literary reputation. As has been seen, he always had many irons in the fire, and was overtaken by death in the prime of life, leaving, as his will shows, many things unfinished, and none of his papers in a state ready for publication. He was surrounded by the best of friends, but time and opportunity, as so often happens in the affairs of busy men, worked against him, and he was well nigh consigned to forgetfulness. . . .
>
> The Hariot manuscripts, of which there are thousands of folio pages all in his own handwriting, seem to be still in the same confused state in which he left them. He directed that the 'waste' should be weeded out of his mathematical papers and destroyed. But this duty seems, fortunately for us, to have been neglected by his executors.

For an account of Harriot's life, about which not a great deal is known, we will quote liberally from Henry Stevens, as he appears to have made a thorough study. Stevens thinks that Harriot's previous biographer, Anthony à Wood, has not done him justice (page 74).

> Hitherto dear quaint old positive antiquarianly slippery Anthony à Wood in his *Athenae Oxoniensis* embodies nearly all of our accepted notions of this great English mathematician and philosopher. Anthony was indefatigable in his researches into the biography of Hariot who was both an Oxford man and an Oxford scholar. He happily succeeded in mousing out a goodly number of recondite and particular occurrences of Hariot's life. He managed, however, to state very many of them erroneously; and he drew hence some important inferences, the reverse, as it now appears of historical truth. . . .
>
> Thomas Hariot was born at Oxford . . . in 1560. He was a 'batelor or commoner of St. Mary's hall. He 'took the degree of bachelor of arts in 1579, and in the latter end of that year did compleat it by determination in Schoolstreet.' Nothing of his boyhood, or of his family, except a few hints in his will, has come to light.

It is not known precisely at what time Hariot joined Walter Raleigh, who was only eight years his senior. From what their friend Hakluyt says of them both, their intimate friendship and mutually serviceable connection were already an old story as early as 1587. . . . On the 22d of February 1588, present reckoning, Hakluyt wrote from Paris to Raleigh in London, . . .

'But since by your skill in the art of navigation you clearly saw that the chief glory of an insular kingdom would obtain its greatest splendor among us by the firm support of the mathematical sciences, you have trained up and supported *now a long time,* with a most liberal salary, Thomas Hariot, a young man well versed in those studies, in order that you might acquire in your spare hours by his instruction a knowledge of these noble sciences; and your own numerous Sea Captains might unite profitably theory with practice.' . . .

From this extract one might perhaps reasonably infer that Hariot went directly from the University in 1580 at the age of twenty into Raleigh's service, or at latest in 1582 when Raleigh returned from Flanders. As our translation of this important passage is rather a free one the old geographer's words are here added, in his own peculiar Latin. . . .

From this early time for nearly forty years, till the morning of the 29th of October 1618, when Raleigh was beheaded, these two friends are found inseparable. Whether in prosperity or in adversity, in the Tower or on the scaffold, Sir Walter always had his Fidus Achates to look after him and watch his interests. With a sharp wit, close mouth, and ready pen Hariot was of inestimable service to his liberal patron. With rare attainments in the Greek and Latin Classics, and all branches of the abstract sciences, he combined that perfect fidelity and honesty of character which placed him always above suspicion even of the enemies of Sir Walter. He was neither a politician nor statesman, and therefore could be even in those times a faithful guide, philosopher, and friend to Raleigh.

In the year 1585, as has already been stated above, Hariot at the age of twenty-five, went out to Virginia in Raleigh's 'first Colonie' as surveyor and historiographer with Sir Richard Grenville, and remained there one year under Governor Ralph Lane, returning in July 1586, in Sir Francis Drake's home-bound fleet from the West Indies. . . . Hariot is known to have spent some time in Ireland on Raleigh's estates there during the reign of Elizabeth, but it is uncertain when. It may have been between the autumn of 1586 and the autumn of 1588. He was in London in the winter of 1588–89 in time to get out hurriedly his report in February 1589. It is possible, however, that he went to Ireland after his book was out. He was probably the manager of one of the estates there as Governor John White was of another in 1591–93.

Of this Virginia report, Stevens says it "must ever serve as the corner-stone of English American History". Johnson (page 178) quotes a sentence from the original report to show that apparently Harriot had a telescope with him on the Virginia expedition. Amongst the instruments listed on the expedition is "a perspectiue glasse whereby was shewed manie strange sightes." This affords another corroboration of the fact that the English group of scientists were familiar with at least some of the principles of telescopes years before the telescope was "invented" in some other country.

In addition to being companion and adviser to Raleigh, Harriot seems to have had much the same standing with Henry Percy, Earl of Northumberland. Stevens says, on page 93:

At what precise time Hariot, who never deserted Raleigh, became acquainted with Henry Percy, Earl of Northumberland, with whose honored name, next to that of Sir Walter's, his must ever be associated, does not as yet appear. It is known, however, that there was an intimacy between Raleigh and Percy as early as 1586. . . . From this time to the day of Raleigh's triumph on the scaffold there exists plenty of evidence of their continued intimacy.

When therefore the Earl and Raleigh were finally caged together in the Tower for life in 1606 their friendship was of more than twenty years' standing. From this we infer that Hariot also knew Percy almost from the time of his joining Raleigh; but the earliest mention of his name in connection with that of the Earl which we have met with is this of 1596, in the Earl's pay-rolls, still preserved at Sion, and described in the Sixth Report of the Royal Commission of Historical Manuscripts, page 227, 'To Mr. Herytt for a book of the Turk's pictures, 7*s*.' It appears from the same rolls that from Michaelmas 1597 to 1610, if not earlier and later, an annual pension of £80 (not £120, or £150, or £300, as variously stated) was paid to Hariot by the Earl. This pension was probably continued as long as Hariot lived; and besides there are not wanting many marks of the Earl's liberality, friendship, and love for his companion and pensioner, who was long known as 'Hariot of Sion on Thames,' as expressed on his monument. On the Earl's accounts for 1608 there is this entry, 'Payment for repairing and finishing Mr Heriotts house at Sion'.

At what time exactly Hariot took up his residence at Sion the Earl's new seat (purchased of James in 1604) is not known, but probably soon after the Earl was sent to the Tower in 1606. There is preserved a Letter from Sir William Lower addressed to Hariot at Sion dated the 30th of September 1607, and other letters or papers exist showing his continued residence there until near the time of his death in 1621. Wood and many subsequent writers to the present time have confused Sion near Isleworth with Sion College in London. They are totally distinct. Hariot had nothing to do with Sion College, which was not founded until 1630, nine years after his death. The error arose out of the coincidence of Torporley's taking chambers at Sion College on retiring from his clerical profession, and dying there in April 1632, leaving his mathematical books and manuscripts to the College Library. He had been appointed by Hariot to look over, arrange, and 'pen out the doctrine' of his mathematical writings. Torporley's abstracts of Hariot's papers are still preserved in Sion College Library. . . .

It is manifest, however, from many considerations that the noble Earl took a lively and almost officious interest in the public honor and character of his friend, for Hariot appears to have been as careless of his own scientific reputation as his contemporary Shakspeare is said to have been of his literary eminence.

On the other hand, Hariot's interest in the Earl's affairs and family at Sion redound greatly to his credit. He was both an eminent scholar and a remarkable teacher. Earnest students flocked to him for higher education from all parts of the country. Besides the private scientific and professional instruction that from the first he gave to Raleigh, his captains and sea officers, he seems to have had under his scientific tuition and mathematical guidance many young men who afterwards became cele-

brated; among whom may be mentioned Robert Sidney, the brother of Sir Philip, afterwards Lord Lisle of Penshurst; Thomas Aylesbury of Windsor, afterwards Sir Thomas, the great-grandfather of two queens of England; the late Lord Harrington; Sir William Protheroe and Sir William Lower of South Wales; Nathaniel Torporley of Shropshire; Sir Ferdinando Gorges of Devonshire; Captain Keymis; Captain Whiddon, and many others. Cordial and affectionate letters of most of these men to their venerated master are still preserved. . . .

The Earl had a large family to be educated, and there is reason to believe that in his absence from Sion Hariot was intrusted for many years with the confidential supervision of some of the Earl's personal affairs at Sion, including the education of his children. . . .

This responsible trust gave Hariot a good house and home of his own at Sion, with independence and an observatory. He had a library in his own house, and seems to have been the Earl's librarian and book selector or purchaser for the library of Sion House, as well as for the use of the Earl in the Tower. The Earl was a great book-collector, as appears by his pay-rolls. Books were carried from Sion to the Tower and back again, probably not only for the Earl's own use, but for Raleigh's in his History of the World. Many of these books, it is understood, are still preserved at Petworth, then and subsequently one of the Earl's seats, but now occupied by the Earl of Leconsfield.

Harriot must have achieved a remarkable feat to keep free of the intrigues of the time and visit both Raleigh and Percy. Indeed, Stevens feels very strongly that Harriot and his knowledge were behind Raleigh's volume, the *History of the World*. Stevens describes these years of Harriot's life as follows, when he was "the ears, the eyes, and the hands of these two noble captives" (page 105):

'Here (at the tower) Raleigh dragged out his long imprisonment, and (as tersely & truly expressed by his son) was, after thirteen years, beheaded for opposing the very thing he was condemned and sentenced for favouring. The whole story is a bundle of inconsistencies, like that of Henry Percy, the 9th Earl of Northumberland, committed to the Tower in 1606, and his fifteen years' imprisonment. The stories of these two celebrated men are inseparably connected with that of Hariot. But it is not our purpose to trace either Raleigh's or Percy's progress through these long and dreary years any further than is necessary to illustrate the life of Hariot, who was the light of the outer world to them both. Incarcerated and watched as they were, Hariot was the ears, the eyes, and the hands of these two noble captives.

The depth of variety of Hariot's intellectual and scientific resources, his honesty of purpose, his fidelity of character, his eminent scholarship, his unswerving integrity, and his command of tongue, rendered him alike invulnerable to politicians and to royal minions. He was with Raleigh at Winchester and in the Tower, off and on, as required, from 1604 to 1618, except during the last voyage to Guiana. He was at the same time a pensioner, a companion, and confidential factotum of his old friend the Earl of Northumberland both in the Tower and at Sion for fifteen years. Watched as these two prisoners were, ensnared, entrapped, and entangled for new evidence against them, it was necessary for Hariot to pursue a delicate and cautious course, to eschew politics, statecraft and treason, and to devote himself

to pure science (almost the only pure commodity that was then a safeguard) metaphysics, natural philosophy, mathematics, history, and literature. He was their jackal, their book of reference, their guide, their teacher, and their friend.

It is against this background that Harriot lived and worked. Small wonder perhaps, that he never got around to publishing his ideas and findings. Even to-day the bulk of the information we possess about him comes from published statements of other people—not from Harriot himself. In our next article we shall enumerate how Harriot had figured that planets were moving in ellipses, not circles, before Kepler announced his laws; why Halley's comet might have been named Harriot's instead, because Harriot had figured an elliptical course for the comet of 1607; how in June 1609, there was a recorded series of telescopic observations of the moon made by Harriot, which may not have been his first observations, and how in 1609 and 1610 he was selling telescopes, constructed by his mechanic Christopher Tooke under his supervision, to his friends.

VARIABLE STAR NOTES

American Association of Variable Star Observers

By Margaret W. Mayall, *Recorder*

The 41st Annual Meeting of the A.A.V.S.O. was held at the Harvard College Observatory on October 17–18, 1952. The Friday evening feature was a lecture by Dr. Donald H. Menzel, "Some Problems of Variable Stars." He outlined the important part astronomy and astronomers have played in gathering, correlating, and applying data obtained from visual, photographic, and radio observations to everyday problems, such as weather forecasts, radio forecasts, and many other problems that are of value, not only in times of peace, but in war as well. He discussed the coronagraph studies of the solar prominences—detail studies of our nearest variable star. Dr. Menzel presented a film showing some of the most recent pictures made with the coronagraph at the Sacramento Peak Station.

At the business session on Saturday morning, Margaret H. Beardsley, Robert M. Greenley, John J. Ruiz, and Domingo Taboada were elected to the Council for the years 1952–1954. The present officers were re-elected: President, Martha Stahr Carpenter; First Vice President, Donald H. Menzel; Second Vice President, Joseph Ashbrook; Secretary, Clinton B. Ford; Treasurer, Percy W. Witherell; Recorder, Margaret W. Mayall.

One life member and 16 new annual members were elected:

Life Member—Roy A. Seely, New York, New York.

Annual Members—William R. Brown, Rosslyn, Va.; Jesse T. Carpenter, Ithaca, N.Y.; Bryant Chester, New Haven, Conn.; Hector R. Durocher, Nashua, N.H., Sheldon Glick, Paterson, N.J.; Leland Haines, Elkhart, Ind.; Ellsworth J. Hedges, Hillsdale, N.J.; Daniel Hess, Mount Joy, Penna.; Shapleigh W. Howell, Yankton, S. Dak.; Harvey Jacobsen, Malden, Mass.; Hector Alvarez Moreno, Santiago, Chile; Toby Owen, Milwaukee, Wis.; Donald A. Rosenfield, Chicago, Ill.; Frank E. Schmelzer, Stow, Mass.; Jerome Wyckoff, Ridgewood, N.J.; Engineering Library, University of California, Los Angeles, Calif.

The following group of papers was presented at the meeting. Mr. R. Newton Mayall is again editing the abstracts, which are to be printed and distributed to members. A copy can be procured by any reader of the Journal by writing to A.A.V.S.O. Headquarters, Harvard College Observatory, Cambridge 38, Mass.

1. Harry Bondy: The Case for Sun-spot Numbers. 2. Harry B. Chase: The New Unitron Telescopes; 3. Thomas A. Cragg: A Sun-spot Crosses the Equator; 4. Demetrius P. Elias: Solar Activity 1951, Athens, Greece; 5. Clinton B. Ford: Lacchini and Ancarani in 1952; 6. Donald S. Kimball: Geographical Extent of a Particular Aurora; 7. Rolland LaPelle: We Must Preserve Our Constant; 8. Robert M. Greenley: Observing Totals 1911–1930; 9. John Streeter: (a) Observations of the Gegenschein, 1952; (b) Delta Cephei—Training Star DeLuxe; 10. Sarah L. Lippincott: Red Dwarf Flare Stars; 11. Herbert A. Luft: No Distortion Visible on the Sun's Limb;

12. Campbell Wade: T Coronae Borealis; 13. William Tifft: Photographic Detection of Variable Stars; 14. B. C. Parmenter: Solar Eyepiece for Sun-spot Colours; 15. George R. Warren: Polarizing Eyepiece; 16. Walter O. Roberts: Colour Phenomena in Sun-spots; 17. Margaret W. Mayall: AE Aquarii Month; 18. John J. Ruiz: Observing with P.E.P.; 19. Paul Stevens: Skalnate Pleso Atlas Mountings for Observing Party.

The reports of the various committees of the A.A.V.S.O. were presented by their respective chairmen. The Recorder's report will be printed in "Variable Comments," and that of the Solar Division in the Solar Division Bulletin. The Chart Curator, Mr. Richard W. Hamilton, reported a most active year. He sent out 200 mailings of charts and atlases to observers in the United States and 17 foreign lands.

Mr. Donald S. Kimball told of his revised method of reporting aurorae. He asks particularly for more observers on the West Coast. Mrs. Margaret W. Beardsley's report of the Occultation Committee showed increased interest in that phase of observing.

During the year ending September 30, 1952, more than 60,000 observations of variable stars were received from 125 observers in the United States and 20 other countries. Reginald P. de Kock, of South Africa, was again the top observer, with 6,692 observations; Cyrus F. Fernald, of Wilton, Maine, was second with 3,056; and Edward G. Oravec of Tuckahoe, New York was third, with 2,536. Five other observers contributed 2,000 or more: Hermann Peter, 2,243; C. J. Renner, 2,178; Paul Ahnert, 2,101; Gunnar Darsenius, 2,068; and Curtis Anderson, 2,000. Thirteen contributed between 1,000 and 2,000; Leslie Peltier, 1,993; William Galbraith, 1,904; Ferdinand Hartmann, 1,865; Giovanni Lacchini, 1,863; Robert Adams, 1,786; David Rosebrugh, 1,665; Thomas Cragg, 1,370; Clinton Ford, 1,293; Domingo Taboada, 1,246; Demetrius Elias, 1,242; R. H. Bicknell, 1,036; M. D. Overbeck, 1,027; Howard LeVaux, 1,020.

The Annual Dinner of the A.A.V.S.O. was held at the Hotel Commander on Saturday night, October 18. The Toastmaster, Richard W. Hamilton, introduced Dr. Shapley, who gave his annual "Highlights of the Year," as follows:

"1. At the top of the list I put the detection of what appear to be the spiral arms of our galaxy through the tracing of the distribution of shining nebulosity in Milky Way fields, the work of W. W. Morgan and his collaborators at the Yerkes Observatory, and for the southern sky by Bart J. Bok and his collaborators in Cambridge and Bloemfontein, South Africa.

"2. The even more spectacular, and still provisional, detection of the spiral arms of our galaxy through the use of radio astronomy's new tool for measuring neutral hydrogen in the space between the stars—the work of van der Hulst, Muller, and Oort in Holland, following the pioneer work of Ewen and Purcell at Harvard, reported as a highlight of last year.

"3. The general acceptance of the growing evidence, produced chiefly at the Harvard and Mount Wilson-Palomar Observatories, that the luminosities of classical Cepheids must be revised upwards, with the consequence that the distances of the Magellanic Clouds, the Andromeda Nebula, and nearly all external galaxies must be appreciably increased; also that the speed of the expansion of the Metagalaxy at a given distance is much less than hitherto figured, and the age of the expansion of the universe increased to where it agrees better with the radioactively determined age of the earth's crust.

"4. The Khartoum eclipse of February 25, which may go down in history as the

most copiously and successfully observed total solar eclipse; the weather was good and the number of scientific participants large.

"5. The analysis at the National Bureau of Standards by Mrs. Charlotte Sitterly and associates of the spectrum of the radioactive element technetium, no. 43, which was first produced in the atomic pile as one of the outstanding contributions of the Plutonic Age in which we live; and the subsequent discovery of the radiations of this element in stars of class S by Merrill and Bowen.

"6. The design by James G. Baker, and the first stages in the construction by Perkin-Elmer and J. W. Fecker, of an important new type of telescope for the observatory of Vanderbilt University—an instrument that combines a 24-inch paraboloid mirror of fused quartz, a 24-inch correcting plate, an 11-inch two-component lens in the converging beam, and a 24-inch six-degree objective prism; the telescope can be used as a regular Newtonian reflector, as a broken Cassegrain reflector, and as a Schmidt-type instrument. The Baker reflector-corrector can transform existing small-field standard reflectors into large-field Schmidt-type instruments.

"7. Identification of two radio stars: in Cygnus as a pair of galaxies apparently in collision, and in Cassiopeia as the expanding envelope of what may have been a supernova of the remote past, by Baade with the collaboration of the English astronomers and radio experts at Cambridge and Manchester.

"8. A theory by E. E. Salpeter of Cornell that provides a method by which the heavier elements, carbon, oxygen, neon, silicon, etc., can be built up in the hot stars out of helium atoms which have been built up from primordial hydrogen; the necessary central temperature of more than a hundred million degrees is found, according to current theory of stellar interiors, in the massive stars of types O and B.

"9. The discovery of the variability, in the shortest known period of eighty minutes, by Eggen of the Lick Observatory working at Canberra, Australia, of a low luminosity, seventh magnitude, nearby star H. D. 223065 in Phoenix, that may be a new type of variable or a variant of the RR Lyrae type.

"10. The remarkable work on the colour-magnitude arrays in some bright globular clusters by Sandage, Arp, and Baum with the Hale telescope—a type of investigation on stellar populations in which your speaker did the pioneer work for giant stars in several globular clusters; the new work is on the way toward making the said speaker obsolete!"

Another item of entertainment at the dinner was a talk by David Rosebrugh on the work he has done on plotting the mean light curves of long period variables for the volume Leon Campbell was working on at the time of his death. Dave finds lots of peculiarities and irregularities in the mean curves. Paul Stevens showed colour slides of the annular eclipse of 1951, and Clinton Ford showed his movies of former A.A.V.S.O. meetings.

Miss Alice Farnsworth closed the dinner with a gracious "thank you" in the form of a comparison of the pleasures of the meeting with the various movements of a symphony.

AE Aquarii. AE Aquarii Month (or Months) was a great success: 1800 observations were made in July, and 1200 in August. Many of the observers became so enthralled with its activities that they continued their observations on into September. Monsieur Rene Lenouval of Haute Provence, France, sent a brief note on his photoelectric photometer observations with a 120-cm. reflector. He has 14 metres of tracings made on 5 consecutive nights, with observations in yellow, blue and ultra-

violet light. He did not catch any of the bright flares our visual observers get, but he found a continuous irregular fluctuation of light, with some rapid increases of several tenths of a magnitude. He found slight variation in yellow light, more in blue, and much more in ultra-violet light. Our visual observers found many flares of seven or eight tenths of a magnitude; sometimes as many as three were observed in one 24-hour period.

Observations received during August and September, 1952: Sixty-three observers contributed 7,337 observations in August, and in September sixty-eight submitted 8,291, making a combined total of 15,628.

	1952					1952			
	August		September			August		September	
Observer	*No. Var.*	*No. Ests.*	*No. Var.*	*No. Ests.*	*Observer*	*No. Var.*	*No. Ests.*	*No. Var.*	*No. Ests.*
Adams, R. M.	63	150	54	132	Knowles, J. H.	...	...	2	12
Ahnert, Paul	...	...	40	659	de Kock, R. P.	144	732	141	618
Ancarani, Mario	22	36	...	...	Koons, L. D.	4	49	48	48
Anderer, J. A.	1	2	10	65	Lacchini, G. B.	120	299	...	...
Anderson, C. E.	183	630	140	550	Leutenegger, Emil	...	...	22	75
Ashbrook, Joseph	12	222	11	49	LeVaux, H. A.	147	175	125	169
Beidler, H. B.	1	1	2	2	Luft, H. A.	6	16	6	41
Bicknell, R. H.	...	...	25	179	Mebius, W. G.	9	9	7	7
Blunck, V. H.	...	...	11	21	Meek, J. W.	...	...	38	320
Bogard, David	...	...	43	92	Melville, E. C.	10	105	18	26
Boutell, H. G.	7	29	8	30	Miller, W. A.	44	54	67	106
Buckstaff, R. N.	20	53	35	70	Milone, L. A.	35	91	43	49
Carpenter, C. B.	...	...	2	2	Montague, A. C.	39	100	37	39
Chassapis, C.	70	225	...	...	Morrisby, A. G. F.	24	36	...	...
Charles, D. F.	25	55	24	40	Motley, Gary	...	...	39	69
Cobb, H.	...	...	3	4	Olson, E. A.	1	9	...	...
Cragg, T. A.	179	282	196	205	Oravec, E. G.	108	400	69	173
Darling, Birt	44	123	43	193	O'Sullivan, W. H.	8	9	14	19
Darnell, P. B.	1	46	...	...	Overbeek, M. D.	44	111	53	160
Darsenius, Gunnar	36	115	95	468	Parker, P. O.	24	24	21	21
Diedrich, DeL.	...	...	2	2	Pearcy, R. E.	5	12	19	19
Diedrich, George	2	2	5	10	Peltier, L. C.	56	225	57	261
Domke, Klaus	...	...	21	77	Penhallow, William	14	15	...	...
Elias, D. P.	87	473	...	...	Peter, Hermann	...	...	40	507
Escalante, F. J.	...	...	70	86	Petersen, E. V.	1	80	...	...
Estremadoyro, G. A.	...	...	4	4	Reeves, W. P.	...	...	2	4
Fernald, C. F.	213	425	227	630	Renner, C. J.	248	278	246	267
Fernald, E. S.	5	8	17	19	Reynolds, F. H.	1	76	4	198
Ficonetti, Rene	20	32	25	37	Rosebrugh, D. W.	16	232	19	232
Ford, C. B.	191	220	...	...	Ruiz, J. J.	1	111	1	76
Galbraith, W. H.	54	195	51	209	Singer, Burton	3	9	...	...
Goodsell, J. G.	...	...	7	7	Taboada, Domingo	31	98	21	21
Greenley, R. M.	20	20	69	122	Tarbell, E. D.	6	11	10	21
Hales, LaVaughn	3	6	...	...	Upjohn, L. N.	41	41	51	51
Hartmann, F.	113	120	138	178	Venter, S. C.	59	111	66	124
Holloway, J. L.	25	36	13	13	Wells, K. A.	...	...	11	11
Isaak, George	15	85	17	116	Whitehill, S. L.	1	14	...	...
Jerabek, H. S.	21	41	13	16	Wyckoff, Jerome	15	43	13	43
Johnsson, R. G.	8	17	20	23	Yamada, Tatsuo	22	48	32	129
Kelley, L. A.	11	20	7	7	Zahner, D. D.	17	25	24	42
Kelly, F. J.	11	20	8	16					

Nova Search Programme: During the months of June, July, August, and September, reports were received from the following thirteen observers. Listed for each observer is the month of the observation, the areas observed (in italics), the number of nights region was checked, and, finally, the limiting magnitude.

ADAMS, R. M., July—*39, 40, 57, 58:* 4, 8; Aug.—*16, 17, 39, 40, 57, 58, 86, 87:* 4, 8; Sept.—*39, 40, 57, 58, 86, 87:* 2, 8.

BLUNCK, V. H., June—*8, 9, 10:* 1, 6; July—*8, 9, 10:* 1, 6; Sept.—*8, 9, 10:* 4, 6.

DARSENIUS, G., June—*Dome:* 4, 2; *16, 17:* 9, 6; *16, 17:* 1, 5; July—*16, 17:* 1, 4; Aug.—*Dome:* 4, 2; *16, 17:* 8, 6; Sept.—*Dome:* 7, 2; *16, 17:* 12, 6.

DIEDRICH, DeL., July—*40:* 1, 6; *40:* 3, 5; *40:* 1, 4; Aug.—*40:* 1, 4; *40:* 1, 5; Sept.—*Dome:* 1, 2; *40:* 2, 5; *40:* 2, 3.

DIEDRICH, G., June—*56:* 1, 6; *78:* 1, 4; July—*Dome:* 9, 2; *Dome:* 1, 1; *56:* 1, 5; *78:* 4, 6; *78:* 2, 5; *78:* 4, 4; Aug.—*Dome:* 2, 2; *78:* 1, 6; *78:* 1, 4; Sept.—*Dome:* 3, 2; *Dome:* 1, 1; *78:* 3, 6; *78:* 2, 4.

LUFT, H. A., Aug.—*25, 26, 27:* 3, 5; Sept.—*25, 26, 27:* 7, 5.

MAHER, J., July—*Dome:* 7, 2; *59:* 5, 4; *59:* 2, 3; Aug.—*Dome:* 10, 2; *59:* 2, 4. 5; *59:* 1, 3; *59:* 7, 5; Sept.—*Dome:* 16, 2; *59:* 5, 4; *59:* 10, 5; *59:* 1, 6.

RICK, J. J., July—*79:* 3, 5; *79:* 5, 4; Aug.—*79:* 7, 4; *79:* 3, 5; Sept.—*79:* 5, 4.

RICK, L., June—*Dome:* 4, 2; *Dome:* 3, 1; *18, 63:* 3, 4; *63:* 1, 5; July—*Dome:* 7, 2; *18:* 4, 5; *18:* 3, 4; *63:* 6, 5; *63:* 2, 4; Aug.—*Dome:* 1, 1; *Dome:* 9, 2; *10:* 9, 5; *10:* 1, 4; *63:* 9, 5; *63:* 1, 4; Sept.—*Dome:* 8, 2; *18:* 3, 4; *18:* 5, 5; *63:* 1, 4; *63:* 9, 5.

ROSEBRUGH, D. W., June—*Dome:* 3, 3; *1:* 3, 4; July—*Dome:* 7, 3; *1:* 4, 4; Aug.—*Dome:* 9, 3; *1:* 1, 4; *1:* 2, 1; Sept.—*Dome:* 9, 3; *1:* 4, 4; *34:* 2, 4.

SMITH, F. W., June—*3, 4:* 3, 6; July—*3, 4:* 2, 6; Aug.—*3, 4:* 2, 6; Sept.—*3, 4:* 8, 6.

WELLS, K. A. Sept.—*1 to 22:* 3, 4.

YAMADA, T., June—*57:* 6, 6; Aug.—*57:* 7, 6.5; *19:* 1, 6.5; Sept.—*57:* 17, 6.5; *19:* 6, 6.5.

Harvard College Observatory
Cambridge 38, Massachusetts
October 19, 1952.

NOTES FROM OBSERVATORIES

Dominion Astrophysical Observatory, Victoria, B.C.

Visitors. The combined meeting of the American Astronomical Society and the Astronomical Society of the Pacific at the end of June (described in the previous issue of this Journal) brought to Victoria possibly the largest group of visiting astronomers in the Observatory's history. Since June other visitors have included: Prof. Jean Lecomte, Director of Research of the French National Scientific Research Centre, Paris; Dr. L. H. Aller of the University of Michigan, Ann Arbor; Dr. Gianola of the Physics Department of the University of British Columbia; and Mr. and Mrs. C. A. Bell of the Windsor Centre of the Royal Astronomical Society of Canada.

Summer Staff. In addition to the casual visitors, the staff of the Observatory is usually augmented during the summer months. This year the members of the summer staff were as follows:

Prof. R. J. Trumpler, who recently retired from the staff of the Leuschner Observatory, University of California, Berkeley. He has recently, with Prof. H. Weaver as co-author, written a book on statistical astronomy, and is engaged in completing his monumental work on galactic clusters.

Dr. M. Wrubel, of the Department of Astronomy of the University of Indiana, Bloomington. Working with K. O. Wright, Dr. Wrubel began a study of line intensities in the spectrum of Procyon, to be applied in his theoretical calculations concerning curves of growth.

Mr. John Galt, of the Physics Department of the University of Toronto. With P. E. Argyle, he constructed a photoelectric photometer for use with the 72-inch telescope.

Mr. John L. Climenhaga, of the Physics Department of Victoria College. He collaborated with A. McKellar in a study of the intensity profiles of the C_2 bands in the spectra of several comets.

Mr. John Maybank, who is now doing graduate study in the Department of Physics at the University of British Columbia. He worked on several projects in spectrophotometry, principally one in which J. A. Pearce is measuring the equivalent widths of $H\gamma$ in the spectra of a considerable number of O-type stars.

Mr. John Merner, now a student at the University of British Columbia. He did seismological work for W. G. Milne both at the Observatory and in the field.

Addition to the Office Building. The construction of the long-sought and much needed addition to the Observatory's office building was authorized this spring. The plans prepared by the architects of the Department of Public Works in Ottawa called for a building that is not only sturdily constructed, largely of concrete blocks, but also one that is of pleasingly modern appearance. It has facilities that should provide ample and suitable space for several decades.

New Spectrograph. Several years ago a new stellar spectrograph of unique design was planned for the 72-inch telescope. There are two novel features of this instrument. The first is that the plate carrying all the optical parts is mounted in such a way as to minimize if not completely eliminate mechanical flexure. This is accomplished by supporting the plate with a system of levers in much the same manner as the mirrors of large telescopes are supported. The second feature is the use of a large flat optical plate, upon which various arrangements of the optical parts are easily made; the plate is accessible by means of two large doors. The new spectrograph has thus a true claim to being called a "universal" spectrograph. The spectrograph, made wholly of aluminum, was attached to the telescope in June 1952, and the adaptation of the various optical combinations of prisms, gratings, cameras, etc., is now in progress.

REVIEW OF PUBLICATIONS

La Construction du Téléscope d'Amateur, by Jean Texereau. Pages 136; 9½ x 6¼ inches; paper bound. Paris, Société Astronomique de France, 1951.

There are many books covering the field of amateur telescope making in all its forms. This volume written in French describes the building of a six-inch reflector from the considerations of the optical properties of a mirror to the final mounting on a thoroughly adequate tripod. Any enthusiastic amateur armed with a copy of this book should be able to produce a satisfying and usable reflector.

The stages and procedures are fully described and illustrated. The reviewer has assisted in building a mounting for a reflector from the working drawings in this book and recommends the design as sturdy and yet easily constructed with a minimum of tools.

G. F. L.

NOTES AND QUERIES

Mr. Bawtenheimer's Observatory

Mr. David Bawtenheimer, a member of the Windsor Centre and a furniture salesman in Windsor, has in his garden an observatory housing a 10-inch reflecting telescope. Although he did not figure the mirror, Mr. Bawtenheimer constructed the mounting and the dome—no small feat, requiring about three years to complete. The dome is 13 feet in diameter and has a revolving aluminum-covered roof with the standard slit opening. Mr. and Mrs. Bawtenheimer are most generous with their time and their equipment, entertaining and instructing interested amateurs who come to their place either singly or in groups. Each June the Windsor Centre is invited to hold a meeting at the Bawtenheimers' observatory. It is a pleasure to see an amateur persevere with the problems of constructing such an observatory, and after completion, carry on the satisfying work of teaching others.

R. J. N.

Crater Elegante: A Caldera

A reference to "Crater Elegante" in the northern part of the State of Sonora, Mexico, appears on p. 166 of this Journal for July-August, 1952. I should like to report that in January 1951, I had the opportunity of visiting and examining this crater in the company of Mr. William C. Miller of the Mount Wilson Observatory, Dr. Richard H. Jahns, Professor of Geology in the California Institute of Technology, and two graduate students from the Institute. In the opinion of all of us, there is no question whatever that Crater Elegante, which is indeed a magnificent feature and well deserves its name, is what geologists call a *caldera*—i.e., "a crater, often of large area, formed by the collapse or subsidence of the central part of a volcano"; it is almost certainly *not* a meteorite crater; moreover, it is located in a region rich in volcanic cones and every other kind of evidence of volcanic activity.

Frederick C. Leonard
Department of Astronomy,
University of California,
Los Angeles, Calif.

Flare Stars

Recently, the interest of astronomers has been stirred by a sudden flaring of UV Ceti, also known as Luyten's flare star. Several years ago Dr. Luyten reported sudden flares of the fainter component of this dwarf red double star. Old plates taken at Harvard were studied to see if any other instance of variability could be detected. The brightest flare (October 7, 1929) involved a change of nearly forty times in the brightness of the fainter component. In this star's most recent flare, the recording pen left the paper after a rise of about 0.8 magnitudes. From comparison of the flare star with other stars in the field, the intensity of the flare was estimated at about 2.5 magnitudes. The star, ordinarily invisible in the finder, was conspicuous during the flare. The most astounding fact is that the total time from the beginning of the flare to the return to normal brightness was about four minutes!

So far no other stars having such an extreme range in brightness over such a short time interval have been discovered. The next most famous flare star is Krüger 60B. It also is the fainter component of a dwarf red double star system. Photographs have been taken of it in a sequence showing it at normal brightness on one exposure, and on an exposure taken three minutes later its brightness has increased fourfold.

There are less than ten of these flare stars known at the present time, and they present one more perplexing problem to the astronomer, who must account for this strange behaviour.

Barbara Creeper

Death of John Himes Pitman

John Himes Pitman, Associate Professor of Astronomy at Swarthmore College, passed away on September 23 at the age of sixty-two. He had been on the staff of Swarthmore College since 1913, teaching both mathematics and astronomy. Together with Dr. John A. Miller, he began the astrometric work of Sproul Observatory and took part in it for nearly four decades. His principal published contributions were in the field of parallaxes and mass-ratios. He was an active member of the American Astronomical Society, which in 1941 made him chairman of the Teachers' Committee. His life and work were an example of unselfishness and cheerful devotion.

Peter van de Kamp

MEETINGS OF THE SOCIETY

AT TORONTO

April 29, 1952.—The meeting was held in the McLennan Physics Laboratory with Mr. F. L. Troyer, President, in the chair.

On a motion by Miss B. R. Creeper, seconded by Miss R. J. Northcott, by-law II of the constitution was suspended so that William K. McLean, 315 Danforth Ave., Toronto, was nominated and elected at this last meeting of the season. The following were also elected:

Howard D. Griffin, 16 Edgewood Cres., Toronto
Frederick Mahler, 53 Baby Point Cres., Toronto
John G. Pound, 30 Rowland St., Toronto
Edward Horrocks, 37 Ball Ave. E., Merritton, Ont.
Robert R. Price, 34 Margueretta St., Toronto.

Mr. Edward Greenwood gave a summary of the celestial events of the coming summer. This was followed by a discussion about what the amateur astronomer could do to help the professional. Under Miss Northcott's leadership variable stars, sun-spots, auroral displays and meteors were discussed from the point of view of amateur observation.

With a reminder of the Toronto Centre "Campus Nights", the meeting was then adjourned by Mr. Troyer.

October 7, 1952.—The meeting was held at the David Dunlap Observatory, Richmond Hill. The President, Mr. F. L. Troyer, was in the chair.

A report on the attendance at the Canadian National Exhibition was given and it was gratifying to hear that more than 10,000 people looked through the telescopes there, the largest number on our record.

It was moved by Mr. Kennedy and seconded by Miss Northcott that a letter of sympathy should be sent to Mrs. A. R. Clute whose husband was such a firm supporter of the Toronto Centre, and who died on September 16, 1952.

Dr. Heard welcomed the Society on behalf of the staff. After the staff had been introduced to the members, the business meeting adjourned and the tour of the Observatory began. Since the evening was cloudy it was not possible to use the telescopes. However, the 74-inch telescope was demonstrated, as well as the 19-inch reflector and the recently installed 6-inch refractor. For amateur telescope makers there was the grinding machine to examine. There were also exhibits and talks on the various pieces of equipment used to reduce the observations made with the telescope.

BARBARA CREEPER, *Recorder.*

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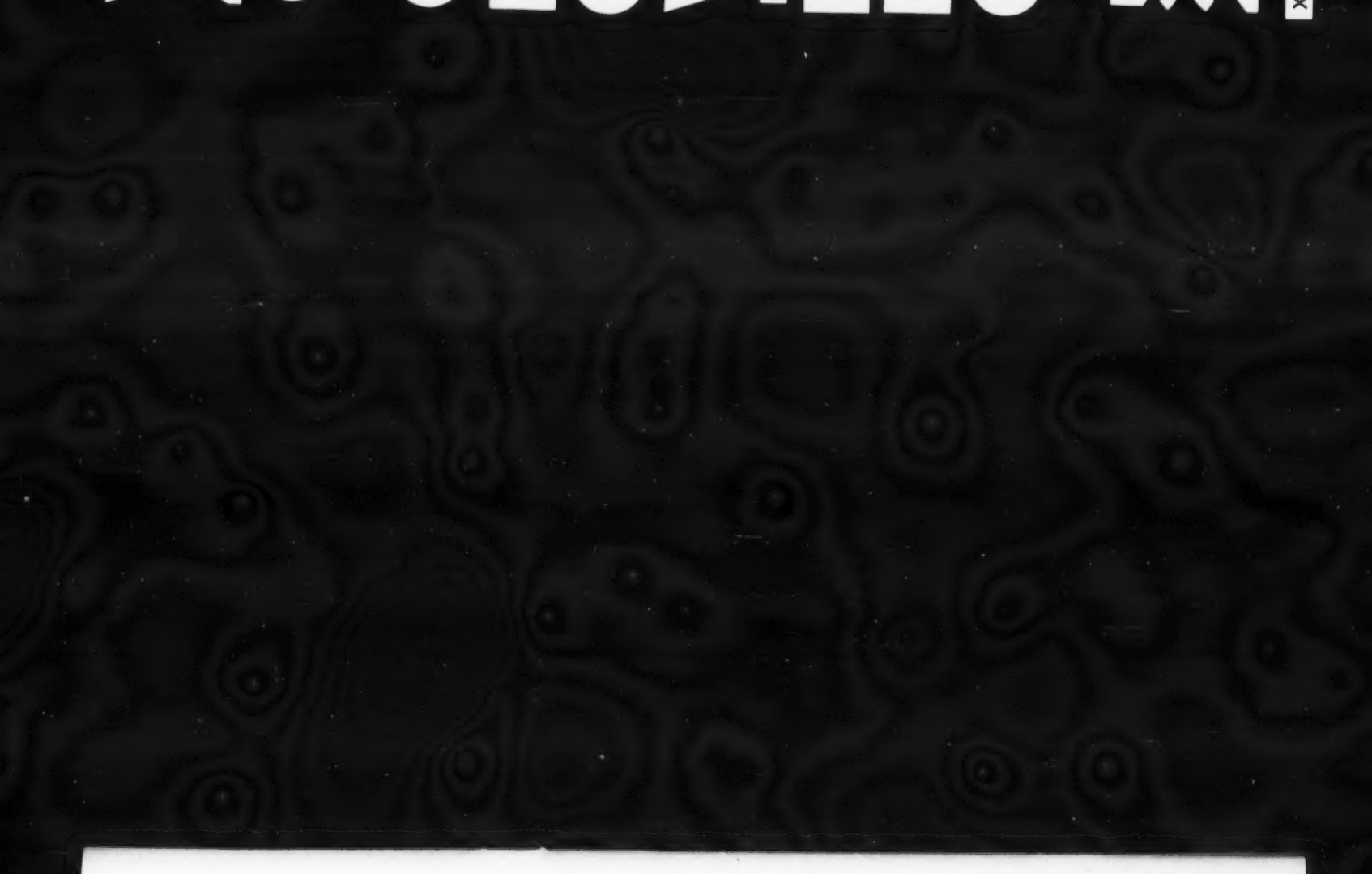

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